Long Term Resource Monitoring Program

Program Report

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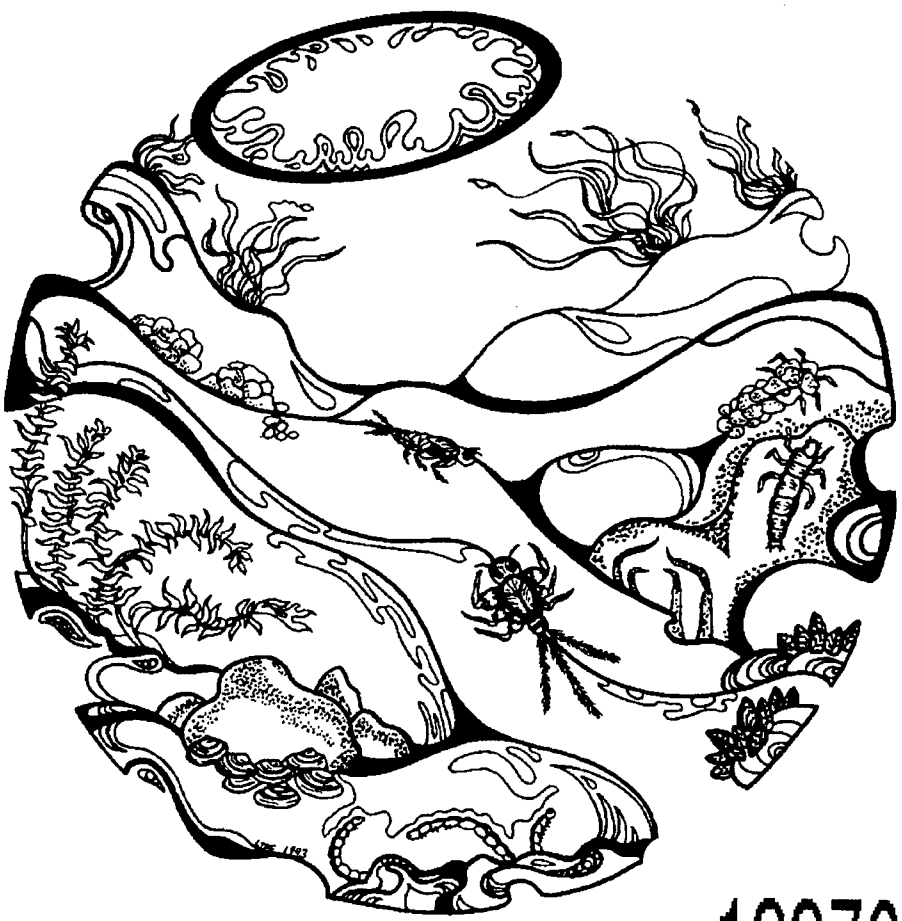
Annual Status Report, 1995: Macroinvertebrate Sampling



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Annual Status Report, 1995: Macroinvertebrate Sampling

by

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April 1997

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Preface

The Long Term Resource Monitoring Program (LTRMP) was authorized under the Water Resources Development Act of 1986 (Public Law 99-662) as an element of the U.S. Army Corps of Engineers' Environmental Management Program. The LTRMP is being implemented by the Environmental Management Technical Center, a U.S. Geological Survey science center, in cooperation with the five Upper Mississippi River System (UMRS) States of Illinois, Iowa, Minnesota, Missouri, and Wisconsin. The U.S. Army Corps of Engineers provides guidance and has overall Program responsibility. The mode of operation and respective roles of the agencies are outlined in a 1988 Memorandum of Agreement.

The UMRS encompasses the commercially navigable reaches of the Upper Mississippi River, as well as the Illinois River and navigable portions of the Kaskaskia, Black, St. Croix, and Minnesota Rivers. Congress has declared the UMRS to be both a nationally significant ecosystem and a nationally significant commercial navigation system. The mission of the LTRMP is to provide decision makers with information for maintaining the UMRS as a sustainable large river ecosystem given its multiple-use character. The long-term goals of the Program are to understand the system, determine resource trends and effects, develop management alternatives, manage information, and develop useful products.

This document is an annual summary for 1995, containing a synthesis of target macroinvertebrate populations in the UMRS. This report satisfies, for 1995, Task 2.2.7.4, *Evaluate and Summarize Annual Results* under Goal 2, *Monitor Resource Change*, as specified in the Operating Plan for the Long Term Resource Monitoring Program (USFWS 1993). This report was developed with funding provided by the Long Term Resource Monitoring Program.

Annual Status Report, 1995: Macroinvertebrate Sampling

by

Jennifer S. Sauer

Abstract

In 1992, macroinvertebrate sampling was initiated in Pools 4, 8, 13, 26, the Open River reach of the Mississippi River, and La Grange Pool of the Illinois River as part of the Long Term Resource Monitoring Program. Long-term monitoring is needed to detect population trends and local changes in aquatic ecosystems. Mayflies (Ephemeroptera), fingernail clams (Sphaeriidae), and the exotic *Corbicula* species were selected for monitoring. Midges (Chironomidae) were added to the sampling design in 1993 and zebra mussels (*Dreissena polymorpha*) were added in 1995. Mayflies, fingernail clams, and midges, members of the soft-substrate community, were chosen because they play an important ecological role in the Upper Mississippi River System. Sampling was based on a stratified random design and was conducted at about 125 sites per study area. Mean densities of organisms were weighted by strata for pool or reachwide estimates. Pools 4 and 13 had the highest mean number of mayflies (178.4 and 181.6 m^{-2}, respectively) and midges (81.5 and 39.8 m^{-2}, respectively). Fingernail clam estimated mean densities were highest in Pool 13 (276.3 m^{-2}). Overall, the impounded areas, including Lake Pepin, and the contiguous backwaters tended to support the highest densities of mayflies, fingernail clams, and midges. Substrates with predominantly a silt clay constituent supported the highest mean densities of mayflies, fingernail clams, and midges.

Introduction

In 1986, Congress designated the Upper Mississippi River System (UMRS), which consists of the Upper Mississippi and Illinois Rivers and several important tributaries, as a nationally significant ecosystem and a nationally significant navigation system. In 1992, macroinvertebrate sampling was initiated in Pools 4, 8, 13, 26, the Open Reach of the Mississippi River, and La Grange Pool of the Illinois River as part of the Long Term Resource Monitoring Program (LTRMP). Mayflies (Ephemeroptera), fingernail clams (Sphaeriidae), and the exotic *Corbicula* species were selected for monitoring. Midges (Chironomidae) were added to the sampling design in 1993 and zebra mussels (*Dreissena polymorpha*) in 1995. These organisms, found in the soft-sediment substrate, were chosen because they play an important ecological role in the UMRS. The exotic *Corbicula* species and zebra mussels were chosen for sampling because of possible detrimental effects they may have on the economy and biology of the UMRS. Further background information can be found in Sauer (1996).

The objective of the LTRMP macroinvertebrate component is to annually monitor and report trends in the status and distribution of select macroinvertebrate populations. The publically available data and annual status reports are the most basic LTRMP products. These annual status reports provide more detailed summaries of macroinvertebrate data than are included in trend reports (Sauer 1997). This status report and the trend reports are best used as information sources for assessment of background variation (Lubinski 1993), identification of management problems, and formulation of hypotheses. The ultimate goal of the LTRMP is not simply to report status and trends, but to improve the understanding and management of the UMRS. That goal can best be achieved by the integration of routine monitoring with experimental research directed at identifying the causes of and solutions to specific problems. Future LTRMP efforts will integrate more narrowly focused analyses of data from all LTRMP monitoring components (limnology, bathymetry, sediments, aquatic plants, and fisheries) with results of experimental studies to identify causes of problems and opportunities for improved management. The resulting syntheses will be the ultimate products of the LTRMP.

Methods

Sampling Procedures

The sampling of mayflies (Ephemeroptera), fingernail clams (Sphaeriidae), midges (Chironomidae), *Corbicula* sp., and zebra mussels was conducted during 1995 in Pools 4, 8, 13, 26, and the Open Reach of the Mississippi River, and La Grange Pool of the Illinois River (Figure 1). Sample coverage was incomplete in 1995 because of flooding in the Pool 26 study area.

Sampling was conducted at about 125 sites per study reach per year (Table 1; Figures 2–7). Sample allocation was based on several criteria: surface area of the aquatic area in each study reach, field station input on accessibility, and productivity of organisms in each aquatic area. All sites were sampled in spring 1995 (Table 2).

Sites included locations where benthic samples were collected historically and randomly selected sites distributed among key aquatic areas, which are based on enduring geomorphic features (Wilcox 1993): contiguous backwaters (BWC), areas that have apparent surface water connection with the rest of the river; main channel borders (MCB), the area between the navigational buoys and the riverbank—not including revetments and channel-training structures; impounded areas (IMP), areas that are large, mostly open-water areas located in the downstream portion of the navigational pools; and side channels (SC), channels that carry less flow than the navigational channel. For Pool 4, the "impounded" area is in the form of Lake Pepin, a tributary delta lake (TDL) formed by the Chippewa River. For the present report, only randomly selected sites will be discussed.

The LTRMP developed a spatial database of aquatic areas (Owens and Ruhser 1996) on the basis of aerial photography made in 1989; this database is used for randomized selection of sampling sites and the quantification of sampling strata reported herein. Ongoing change detection requires that this database be updated at appropriate intervals. The LTRMP Operating Plan (USFWS 1993) prescribes future repetition of aerial photography. Additionally, the LTRMP updates sampling maps, as needed, from direct observations made by the sampling crews.

Macroinvertebrate sampling procedures are described in detail in the LTRMP Procedures Manual (Thiel and Sauer 1995). Benthic samples were collected with a winch-mounted 23- × 23-cm (0.052-m^2) standard Ponar grab sampler (Ponar Grab Dredge, Wildlife Supply Company, Saginaw, Michigan). The sieve size of the Ponar wash frame was a U.S. Standard No. 16 (1.18 mm). Thus, inferences in macroinvertebrate numbers made from this data for this report are restricted to the larger organisms of the population whole (i.e., adults). Mayflies, fingernail clams, midges (greater than 1 cm), *Corbicula* sp., and zebra mussels were counted and picked in the field.

Quality Assurance

After the picking process was complete and only detritus and organisms other than mayflies, fingernail clams, midges, *Corbicula* sp., and zebra mussels were left, it was determined if the sample would be returned to the lab for quality assurance (QA) procedures (Norris and Georges 1992). Randomly selected samples from 10% of the sites (within each aquatic area) were returned to the lab. The results from laboratory-sorted samples were compared with those from samples sorted in the field to determine sorting efficiency.

Site Information

Substrate composition was noted according to subjective characterization. Six categories of substrate composition were used: hard clay, silt clay, silt clay with sand, sand with silt clay, sand, and gravel rock.

The percentage of submersed and floating-leaved aquatic vegetation in the column of water and sediment that the Ponar dredge fell through was recorded. Also, the type and percentage of vegetation and open water in a 15-m radius from the boat were characterized. Water depth was also measured at each site.

Statistical Analyses

Total catch is recorded for each target organism from individual Ponar samples. Whenever a species is not caught in a sample, the catch for that species in that sample is zero.

Analyses of densities (*DS*) in the present report are based on estimates of mean densities obtained by pooling data over all strata chosen for macroinvertebrate sampling (Sauer 1997). In this way, the analyses track the broadest possible spatial scale in relative densities. The pooling probably presents a truer image of reachwide trends in true densities because it does not rely only on particularly favorable habitats. If the quantity of preferred habitat declines through time while densities in those preferred habitats remains constant, then these pooled mean *DS* statistics should also reflect that decline, whereas mean *DS* statistics from only the preferred habitats would not. The LTRMP monitors both the composition of aquatic areas and macroinvertebrates. Therefore, if the quantity of that aquatic area class preferred by a particular species declines through time while the abundances within each aquatic area remain constant, then the pooled mean *DS* statistics should also reflect the resulting decline in reachwide abundance, whereas mean *DS* statistics from only the preferred aquatic area would not.

The estimates of pooled reachwide mean *DS* were obtained from the conventional design-based estimator for stratified random samples (Cochran 1977). For an arbitrary random variable denoted y (for this report y is *DS*), the pooled mean, denoted $\bar{y}_{st}$ (*st* for stratified) is given by

$$\bar{y}_{st} = \frac{1}{N}\sum_{h=1}^{L} N_h \bar{y}_h \qquad (1)$$

where N_h is the number of sampling sites within stratum h, $N = \Sigma_{h=1}^{L} N_h$, and $\bar{y}_h$ denotes the estimator of the sample mean of y for stratum h. The estimator of the variance of $\bar{y}_{st}$ is

$$s^2(\bar{y}_{st}) = \frac{1}{N^2}\sum_{h=1}^{L} N_h(N_h - n_h)\left(\frac{s_h^2}{n_h}\right) \qquad (2)$$

where

$$s_h^2 = \frac{\sum_{i=1}^{n_h} (y_{hi} - \bar{y}_h)^2}{n_h - 1}$$

is the usual estimator of the variance of y_h and n_h is the number of samples taken in stratum h (Cochran 1977). The standard error of $\bar{y}_{st}$ is therefore $s(\bar{y}_{st})$. For LTRMP macroinvertebrate monitoring, the sampling units are the 50-m^2 sampling grids.

Equation (1) is used to obtain estimates of overall mean densities 1992–1995 random sampling. In random samples, equation (1) yields unbiased estimates of the pooled means regardless of the probability distribution of y (Cochran 1977).

Summary

- Measured depths at sampling sites ranged from 0.3 to 13.4 m with a mean of 3.3 m.
- In all study reaches, more than 85% of the Ponar grabs contained no submersed or floating-leaved vegetation (Table 3).
- The majority of samples taken in all reaches were in open water surrounded by little vegetation (Tables 4–7).
- Macroinvertebrate samples ($N = 626$) in 1995 produced a total of 2,269 mayflies, 2,035 fingernail clams, 1,354 midges, 16 *Corbicula* sp., and 197 zebra mussels.
- Mean densities of target organisms were weighted by strata selected for macroinvertebrate sampling (Sauer 1997) to estimate pool or reachwide means (Table 8). Pool 13 consistently had the highest densities of mayflies, fingernail clams, and midges. Low numbers of *Corbicula* species were reported for all study reaches.
- Visual classification of sediments indicated that sample sites in Pools 4, 8, 13, 26, and La Grange Pool were dominated by silt clay. The Open River reach had a predominance of sand (Table 9).
- The IMP aquatic area in Pools 4, 8, 13, and 26 supported the highest numbers of mayflies. Mean densities of fingernail clams were highest in Lake Pepin (Pool 4) and the impounded area of Pool 13 (Tables 10–12).
- The silt clay substrate supported the highest mean numbers of mayflies in all study reaches (Table 13). The silt clay substrate supported the highest mean number of fingernail clams in Pools 4, 8, and 13 (Table 14). Higher densities of midges tended to be found in the finer sediments (Table 15). The silt clay substrate seems to be well suited for burrowing organisms. The silt clay substrates apparently make it easier for burrowing, they still maintain their shape to allow for water movement and food uptake.
- On the average, 0.73 mayflies and 10.5 fingernail clams were found in laboratory samples ($N = 65$). Overall, laboratory-picked mayflies were less than 1.9 mm long and laboratory-picked fingernail clams were less than 4.2 mm long. Some of the fingernail clams recovered from laboratory-picked samples could be attributed to premature release of juveniles from the branchial chambers of adults because of traumas such as washing, transport, and the addition of preservatives (Gale 1969).

Acknowledgments

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Table 1. Macroinvertebrate random sample sites by study reach and aquatic area. Numbers in parenthesis are historical (fixed) sites.

Study reach	Contiguous backwater	Impounded	Side channel	Main channel border
Pool 4	60 (3)	46 (1)	10	10
Pool 8	32 (3)	49 (11)	19 (2)	10
Pool 13	48 (5)	47 (1)	15 (1)	15
Pool 26	40	27	38	19
Open River	—	—	49 (7)	35 (2)
La Grange Pool	42 (18)	—	42 (7)	42 (1)

[a]Pool 4 Impounded = Lake Pepin, Tributary Delta Lake

Table 2. Sampling dates for 1995 macroinvertebrate sampling.

Study reach	Beginning date	Ending date
Pool 4	May 3	May 11
Pool 8	May 22	June 2
Pool 13	May 9	May 19
Pool 26	May 11	May 19
Open River	April 3	April 17
La Grange Pool	May 1	May 10

Table 3. Number of sites, reported as percentages, with submersed and floating-leaved vegetation in the column of water and sediment that the Ponar fell through. *N* = number of samples.

Study reach (*N*)	Vegetation present				
	0%	1%–20%	21%–50%	51%–90%	91%–100%
Pool 4 (120)	93.3	5.8	0.8	—	—
Pool 8 (109)	93.6	5.5	—	0.9	—
Pool 13 (118)	89.0	10.2	0.8	—	—
Pool 26 (69)	94.2	2.9	1.4	1.4	—
Open River (112)	98.2	0.9	0.9	—	—
La Grange Pool (98)	100	—	—	—	—

Table 4. Number of sites, reported as percentages, with submersed vegetation within a 15-m radius from the boat. *N* = number of samples.

Study reach (*N*)	Vegetation present				
	0%	1%–20%	21%–50%	51%–90%	91%–100%
Pool 4 (120)	99.2	0.8	—	—	—
Pool 8 (109)	90.8	7.3	1.8	—	—
Pool 13 (118)	94.9	5.1	—	—	—
Pool 26 (69)	95.7	4.3	—	—	—
Open River (112)	98.2	0.9	0.9	—	—
La Grange Pool (98)	100	—	—	—	—

Table 5. Number of sites, reported as percentages, with floating-leaved vegetation within a 15-m radius from the boat. *N* = number of samples.

Study reach (*N*)	Vegetation present				
	0%	1%–20%	21%–50%	51%–90%	91%–100%
Pool 4 (120)	100	—	—	—	—
Pool 8 (109)	94.5	5.5	—	—	—
Pool 13 (118)	98.3	1.7	—	—	—
Pool 26 (69)	100	—	—	—	—
Open River (112)	100	—	—	—	—
La Grange Pool (98)	100	—	—	—	—

Table 6. Number of sites, reported as percentages, with emergent vegetation within a 15-m radius from the boat. *N* = number of samples.

Study reach (*N*)	Vegetation present				
	0%	1%–20%	21%–50%	51%–90%	91%–100%
Pool 4 (120)	85.0	10.8	2.5	1.7	—
Pool 8 (109)	98.2	1.8	—	—	—
Pool 13 (118)	97.5	2.5	—	—	—
Pool 26 (69)	94.2	2.9	2.9	—	—
Open River (112)	93.8	4.5	0.9	0.9	—
La Grange Pool (98)	100	—	—	—	—

Table 7. Number of sites, reported as percentages, with open water within a 15-m radius from the boat. *N* = number of samples.

Study reach (*N*)	Open water present				
	0%	1%–20%	21%–50%	51%–90%	91%–100%
Pool 4 (120)	—	—	—	18.3	81.7
Pool 8 (109)	—	—	—	2.8	97.2
Pool 13 (118)	0.8	—	—	1.7	97.5
Pool 26 (69)	2.9	—	4.3	1.4	91.3
Open River (112)	0.9	—	2.7	11.6	84.8
La Grange Pool (98)	1.0	—	—	—	99.0

Table 8. Estimated mean number of mayflies, fingernail clams, midges, *Corbicula* sp., and zebra mussels per square meter by study reach. Estimated means are weighted by areas of strata. *N* = number of samples.

Study reach (*N*)	Mayflies (±1 SE)	Fingernail clams (±1 SE)	Midges (±1 SE)	*Corbicula* sp. (±1 SE)	Zebra mussels (±1 SE)
Pool 4 (120)	178.4 (±35.9)	60.9 (±13.2)	81.5 (±13.9)	0.0 (±0.0)	27.2 (±27.2)
Pool 8 (109)	55.9 (±14.2)	6.4 (±3.0)	11.1 (±3.9)	0.0 (±0.0)	0.2 (±0.2)
Pool 13 (118)	181.6 (±51.7)	276.3 (±81.9)	39.8 (±9.4)	0.0 (±0.0)	10.1 (±6.8)
Pool 26 (69)	—	—	—	—	—
Open River (112)	11.7 (±5.5)	0.0 (±0.0)	13.9 (±5.0)	1.8 (±1.1)	2.4 (±2.0)
La Grange Pool (98)	5.7 (±3.5)	15.2 (±8.2)	1.7 (±12.2)	1.4 (±0.7)	9.0 (±9.0)

Table 9. Percentage of predominant substrate type found in Ponar grab samples by study reach. *N* = number of samples.

Study reach (*N*)	Predominant substrate (%)						
	Hard clay	Silt clay	Silt clay with sand	Sand with silt clay	Sand	Gravel rock	Total (%)
Pool 4 (120)	1.7	50.8	15.8	4.2	24.2	3.3	100
Pool 8 (109)	1.8	39.4	16.5	17.4	24.8	—	100
Pool 13 (118)	0.8	65.3	11.9	8.5	12.7	0.8	100
Pool 26 (69)	23.2	68.1	7.2	—	—	1.4	100
Open River (112)	11.6	23.2	8.0	5.4	35.7	16.1	100
La Grange Pool (98)	5.1	42.9	13.3	16.3	21.4	1.0	100

Table 10. Mean number of mayflies per square meter by study reach and aquatic area. *N* = number of samples.

Study reach (*N*)	Aquatic area			
	BWC (±1 SE)	MCB (±1 SE)	IMP (±1 SE)	SC (±1 SE)
Pool 4 (120)	55.6 (±12.6)	57.7 (±57.7)	218.2 (±40.3)[a]	21.2 (±12.3)
Pool 8 (109)	62.0 (±19.5)	1.9 (±1.9)	82.4 (±16.3)	8.3 (±7.1)
Pool 13 (118)	153.8 (±32.4)	110.3 (±87.7)	238.4 (±52.8)	134.6 (±62.3)
Pool 26 (69)	5.2 (±2.4)	—	21.4 (±11.2)	0.0
Open River (112)	—	11.9 (±5.8)	—	10.4 (±3.5)
La Grange Pool (98)	1.6 (±1.1)	7.9 (±5.2)	—	12.6 (±3.9)

BWC = contiguous backwater
MCB = main channel border
IMP = impounded
SC = side channel
[a]Pool 4 IMP = Lake Pepin, Tributary Delta Lake

Table 11. Mean number of fingernail clams per square meter by study reach and aquatic area. *N* = number of samples.

Study reach (*N*)	Aquatic area			
	BWC (±1 SE)	MCB (±1 SE)	IMP (±1 SE)	SC (±1 SE)
Pool 4 (120)	8.2 (±2.6)	6.9 (±3.9)	77.4 (±16.0)[a]	11.5 (±9.6)
Pool 8 (109)	9.9 (±6.3)	3.8 (±3.8)	7.5 (±2.2)	0.0 (±0.0)
Pool 13 (118)	117.1 (±29.2)	58.9 (±37.3)	536.6 (±154.6)	47.2 (±24.5)
Pool 26 (69)	0.9 (±0.7)	—	0.7 (±0.7)	0.0
Open River (112)	—	0.0 (±0.0)	—	0.0 (±0.0)
La Grange Pool (98)	6.4 (±2.9)	19.7 (±11.5)	—	32.9 (±11.7)

BWC = contiguous backwater
MCB = main channel border
IMP = impounded
SC = side channel
[a]Pool 4 IMP = Lake Pepin, Tributary Delta Lake

Table 12. Mean number of midges per square meter by study reach and aquatic area. *N* = number of samples.

Study reach (*N*)	Aquatic area			
	BWC (±1 SE)	MCB (±1 SE)	IMP (±1 SE)	SC (±1 SE)
Pool 4 (120)	116.1 (±16.5)	10.5 (±6.0)	79.2 (±13.9)[a]	11.5 (±5.1)
Pool 8 (109)	12.2 (±3.6)	3.8 (±3.8)	13.3 (±3.5)	9.1 (±7.1)
Pool 13 (118)	93.1 (±17.9)	2.6 (±1.7)	18.2 (±6.9)	1.7 (±1.7)
Pool 26 (69)	45.9 (±17.9)	—	31.3 (±14.9)	0.0
Open River (112)	—	10.1 (±4.1)	—	41.5 ±12.1)
La Grange Pool (98)	54.5 (±24.1)	14.8 (±3.8)	—	50.0 (±14.0)

BWC = contiguous backwater
MCB = main channel border
IMP = impounded
SC = side channel
[a]Pool 4 IMP = Lake Pepin, Tributary Delta Lake

Table 13. Mean number of mayflies per square meter by study reach and predominant substrate type. *N* = number of samples.

Study reach (*N*)	Predominant substrate					
	Hard clay (±1 SE)	Silt clay (±1 SE)	Silt clay with sand (±1 SE)	Sand with silt clay (±1 SE)	Sand (±1 SE)	Gravel rock (±1 SE)
Pool 4 (120	0.0	179.1 (±30.0)	117.4 (±39.3)	30.8 (±26.2)	1.3 (±0.9)	0.0 (±0.0)
Pool 8 (109)	0.0 (±0.0)	117.6 (±19.6)	40.6 (±18.8)	18.2 (±6.7)	0.0 (±0.0)	—
Pool 13 (118)	0.0	236.5 (±36.8)	217.0 (±93.2)	5.8 (±2.9)	0.0 (±0.0)	0.0
Pool 26 (69)	0.0 (±0.0)	16.4 (±6.7)	3.8 (±3.8)	—	—	0.0
Open River (112)	10.4 (±3.5)	28.8 (±10.3)	19.2 (±11.6)	0.0 (±0.0)	3.8 (±3.8)	1.1 (±1.1)
La Grange Pool (98)	0.0 (±0.0)	11.9 (±4.5)	10.3 (±6.0)	8.4 (±8.4)	0.9 (±0.9)	0.0

Table 14. Mean number of fingernail clams per square meter by study reach and predominant substrate type. *N* = number of samples.

Study reach (*N*)	Predominant substrate					
	Hard clay (±1 SE)	Silt clay (±1 SE)	Silt clay with sand (±1 SE)	Sand with silt clay (±1 SE)	Sand (±1 SE)	Gravel rock (±1 SE)
Pool 4 (120)	0.0 (±0.0)	56.7 (±12.1)	15.1 (±5.9)	7.7 (±4.7)	6.6 (±3.1)	0.0 (±0.0)
Pool 8 (109)	38.5 (±38.5)	8.9 (±4.6)	5.3 (±2.6)	7.1 (±3.4)	0.7 (±0.7)	—
Pool 13 (118)	0.0	389.9 (±99.5)	86.5 (±23.9)	42.3 (±18.8)	43.6 (±43.6)	0.0
Pool 26 (69)	0.0 (±0.0)	0.8 (±0.6)	3.8 (±3.8)	—	—	0.0
Open River (112)	0.0 (±0.0)	0.0 (±0.0)	0.0 (±0.0)	0.0 (±0.0)	0.0 (±0.0)	0.0 (±0.0)
La Grange Pool (98)	0.0 (±0.0)	27.0 (±12.1)	45.9 (±21.9)	15.6 (±10.1)	4.6 (±2.9)	0.0

Table 15. Mean number of midges per square meter by study reach and predominant substrate type. *N* = number of samples.

Study reach (*N*)	Predominant substrate					
	Hard clay (±1 SE)	Silt clay (±1 SE)	Silt clay with sand (±1 SE)	Sand with silt clay (±1 SE)	Sand (±1 SE)	Gravel rock (±1 SE)
Pool 4 (120)	0.0 (±0.0)	101.2 (±13.1)	71.9 (±19.7)	130.8 (±57.8)	66.9 (±23.6)	0.0 (±0.0)
Pool 8 (109)	0.0 (±0.0)	17.9 (±4.8)	11.8 (±5.2)	9.6 (±3.9)	1.4 (±0.9)	—
Pool 13 (118)	0.0	61.4 (±11.7)	15.1 (±9.5)	5.8 (±5.8)	1.3 (±1.3)	0.0
Pool 26 (69)	25.2 (±20.3)	41.3 (±14.2)	76.9 (±76.9)	—	—	0.0
Open River (112)	10.4 (±5.2)	98.4 (±29.0)	55.6 (±15.5)	0.0 (±0.0)	1.4 (±0.8)	4.3 (±3.3)
La Grange Pool (98)	7.7 (±7.7)	48.5 (±14.2)	23.7 (±8.8)	19.2 (±7.2)	44.9 (±22.8)	0.0

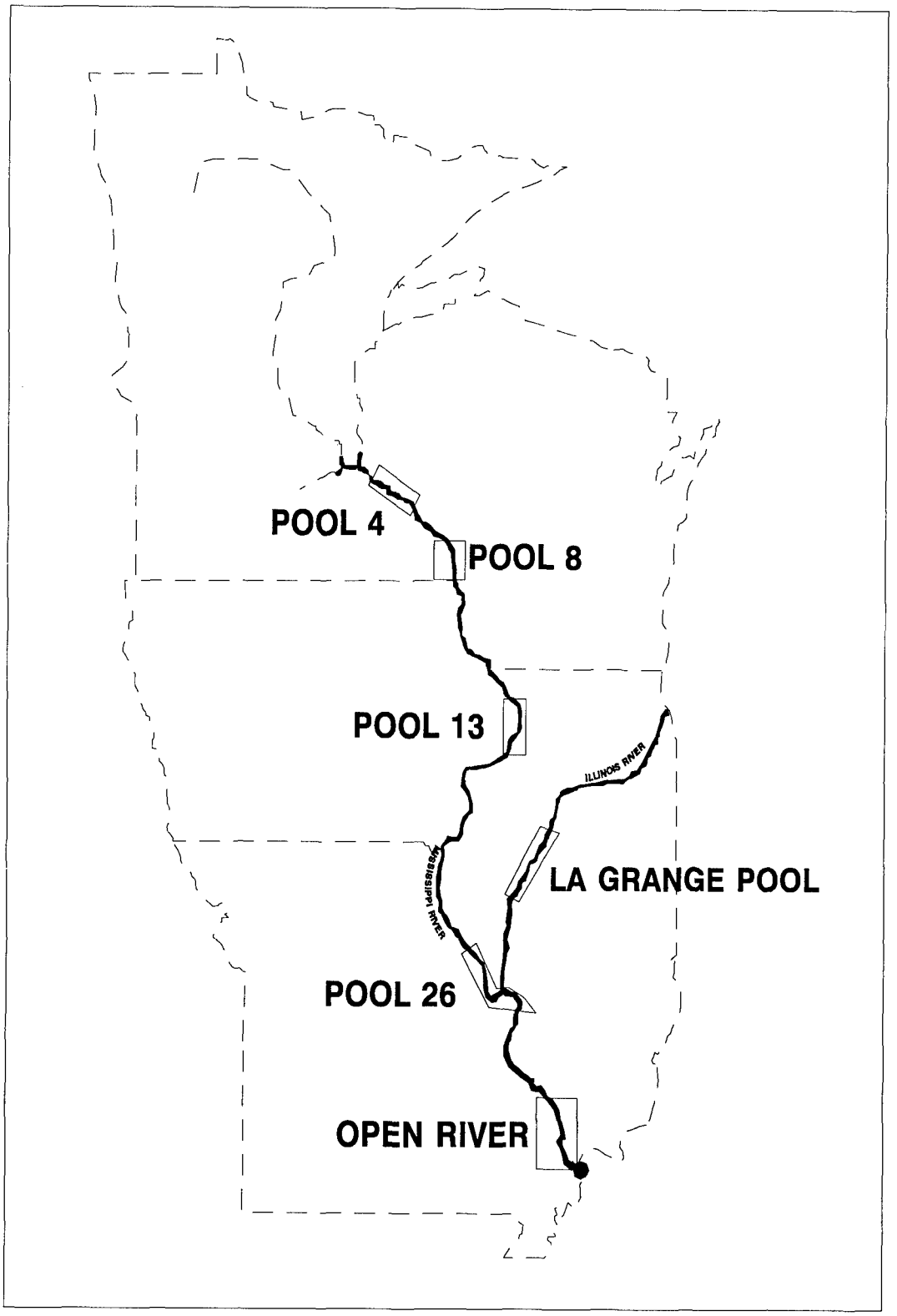

Figure 1. Long Term Resource Monitoring Program study reaches for macroinvertebrate sampling

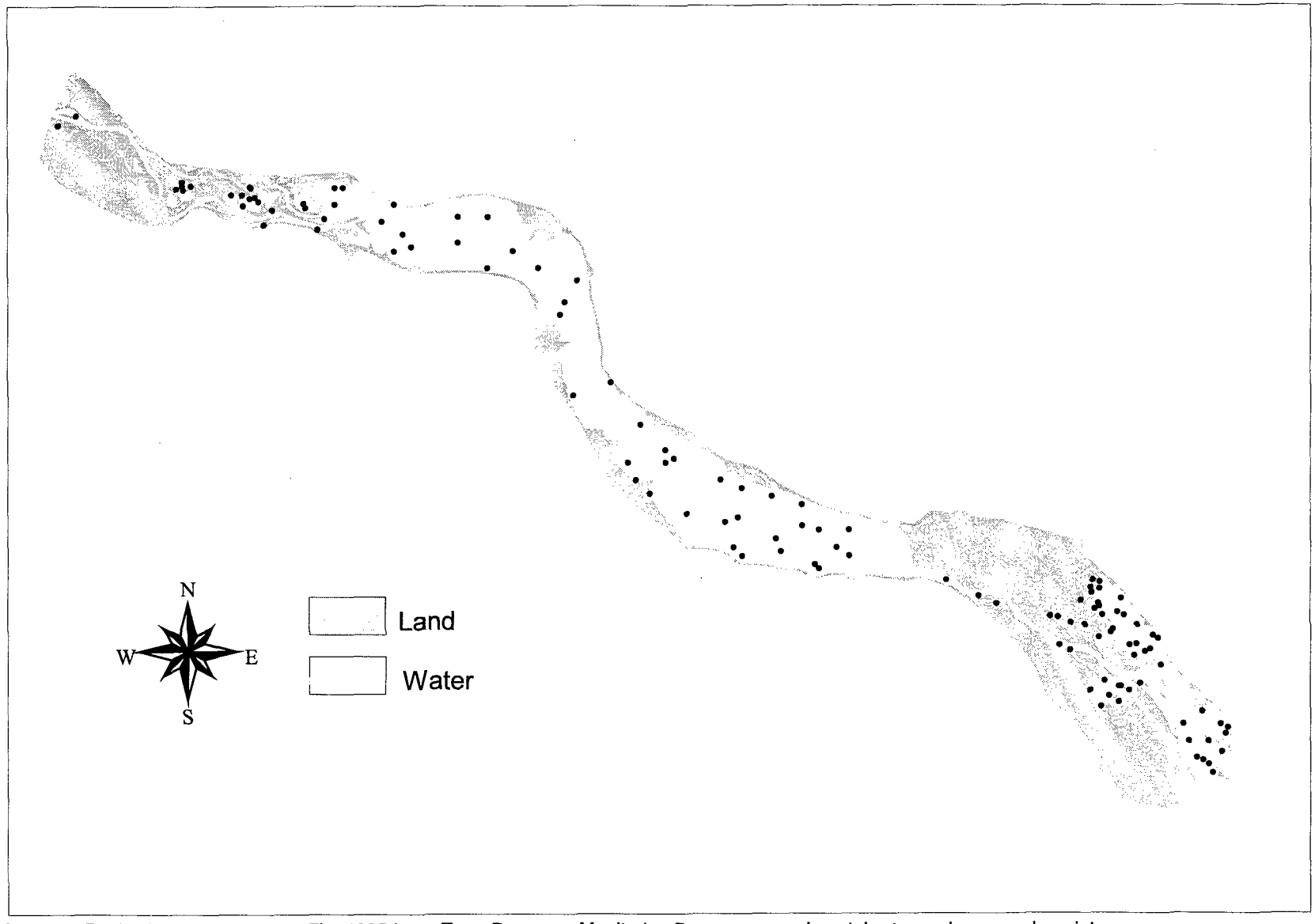

Figure 2. Pool 4 (river miles 753–797)—1995 Long Term Resource Monitoring Program macroinvertebrate random sample points.

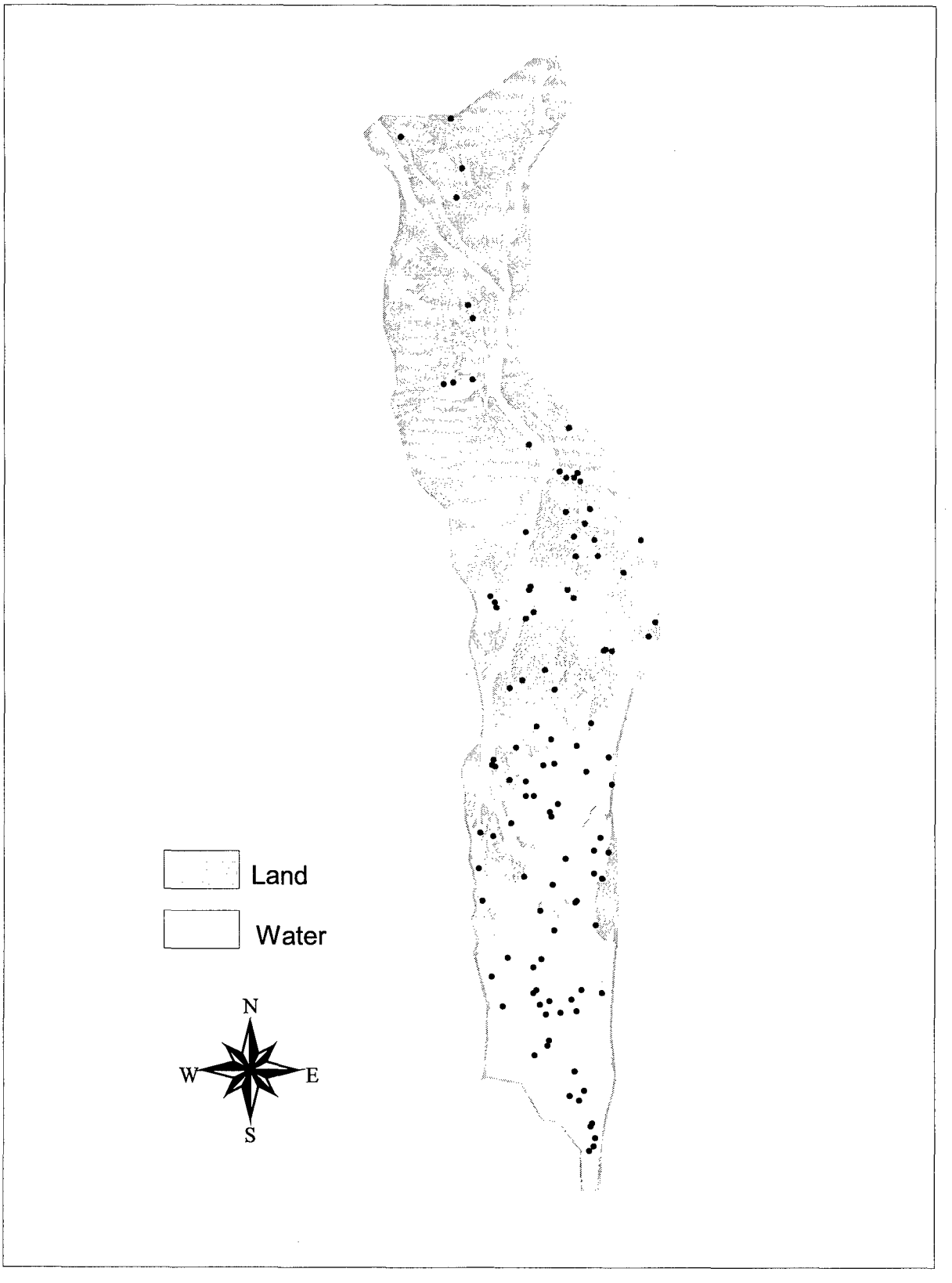

Figure 3. Pool 8 (river miles 679–703)—1995 Long Term Resource Monitoring Program macroinvertebrate random sample points.

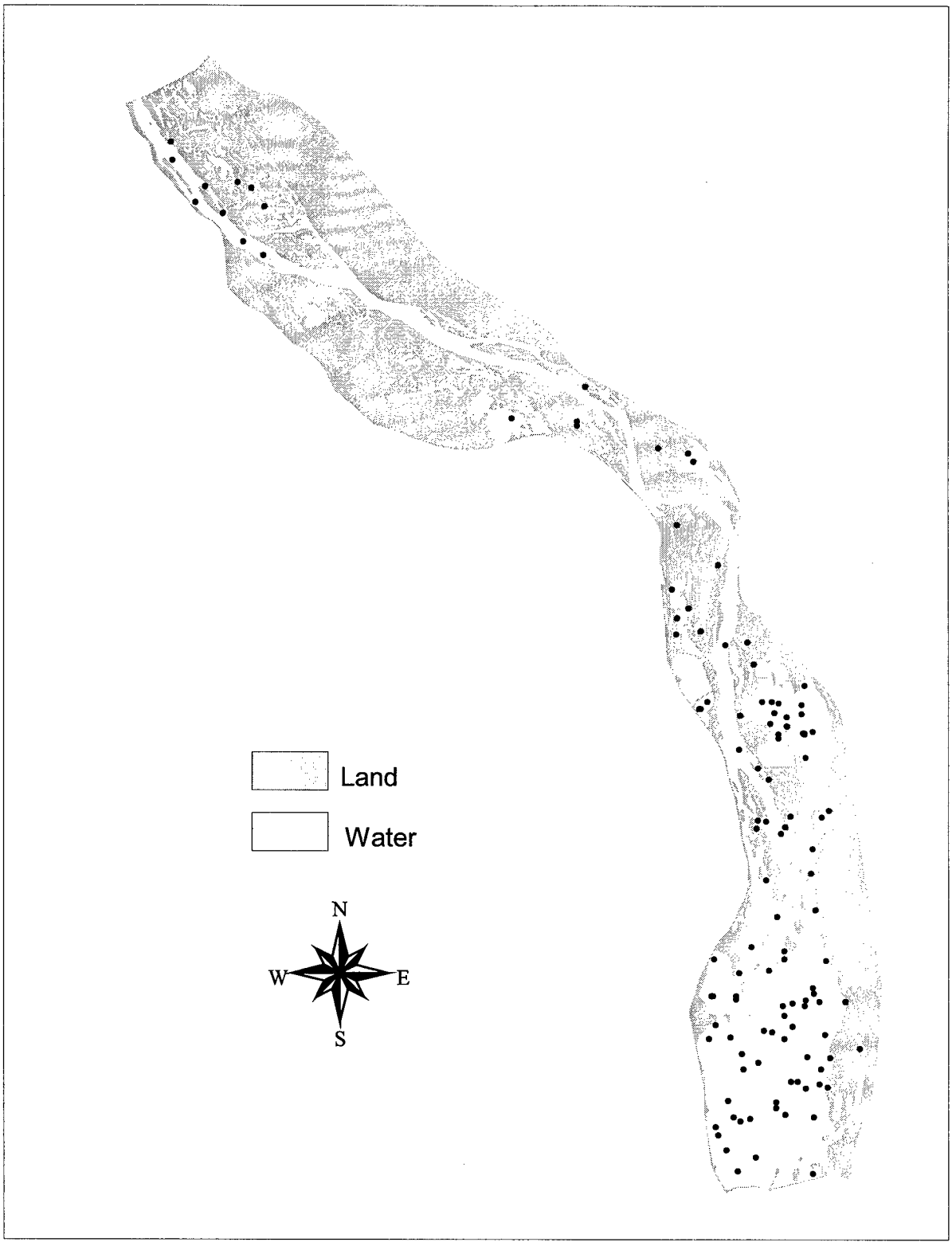

Figure 4. Pool 13 (river miles 522.5–557)—1995 Long Term Resource Monitoring Program macroinvertebrate random sample points.

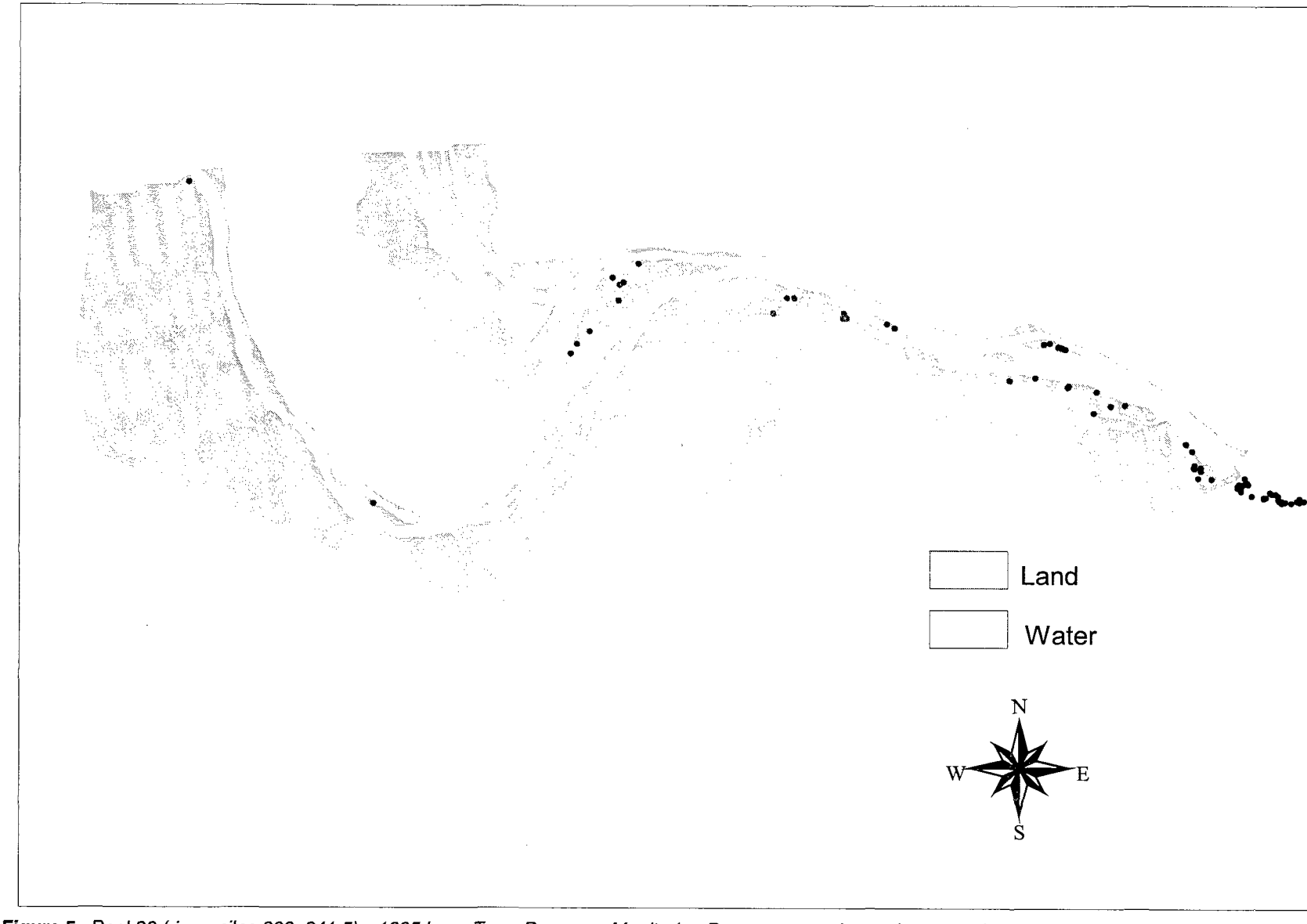

Figure 5. Pool 26 (river miles 203–241.5)—1995 Long Term Resource Monitoring Program macroinvertebrate random sample points.

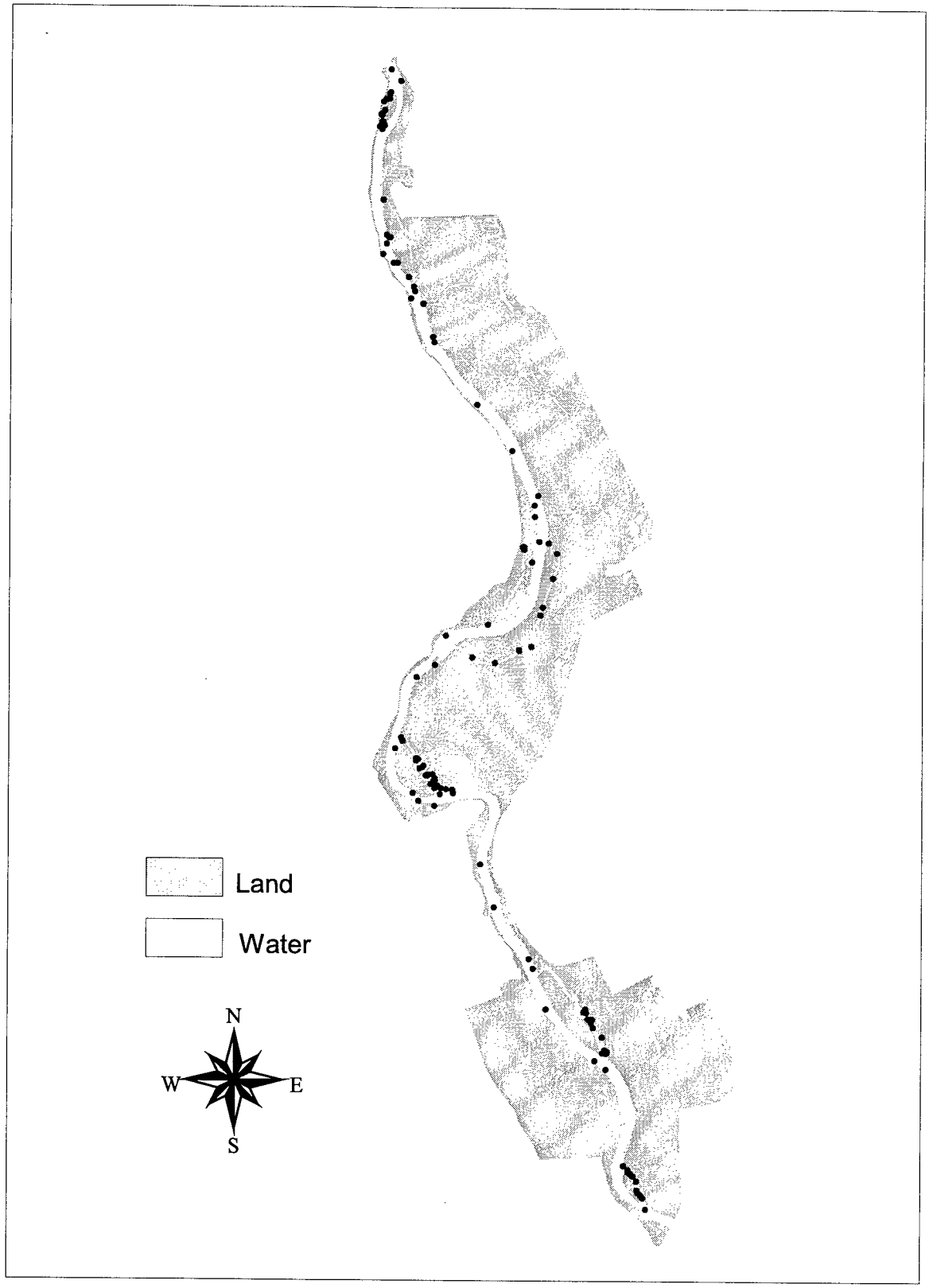

Figure 6. Open River (river miles 0–80)—1995 Long Term Resource Monitoring Program macroinvertebrate random sample points.

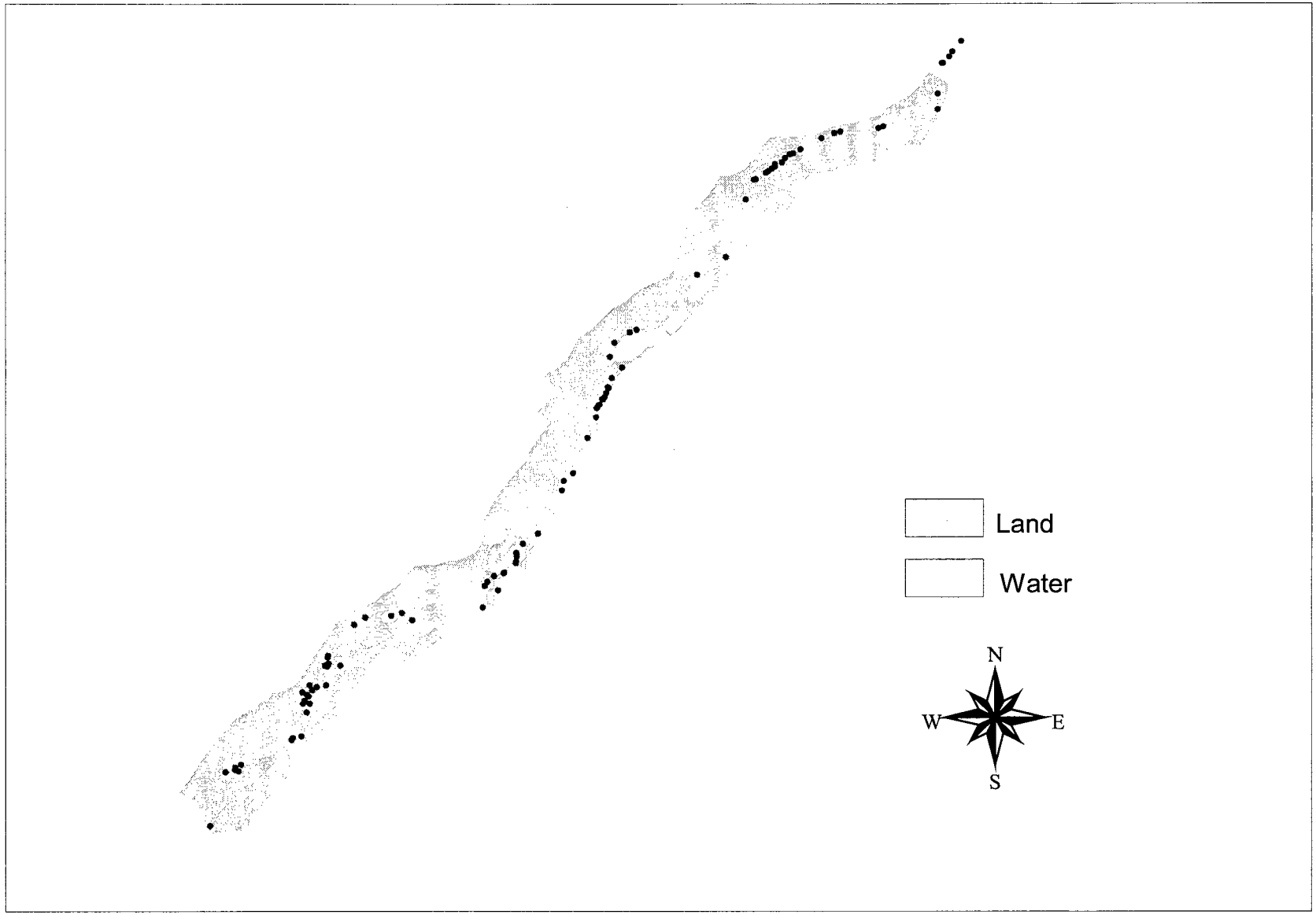

Figure 7. La Grange Pool (Illinois river miles 80–158)—1995 Long Term Resource Monitoring Program macroinvertebrate random sample points.

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13. ABSTRACT (Maximum 200 words)

In 1992, macroinvertebrate sampling was initiated in Pools 4, 8, 13, 26, and the Open River reach of the Mississippi River, and La Grange Pool of the Illinois River as part of the Long Term Resource Monitoring Program. Long-term monitoring is needed to detect population trends and local changes in aquatic ecosystems. Mayflies (Ephemeroptera), fingernail clams (Sphaeriidae), and the exotic *Corbicula* species were selected for monitoring. Midges (Chironomidae) were added to the sampling design in 1993 and zebra mussels (*Dreissena polymorpha*) were added in 1995. Mayflies, fingernail clams, and midges, members of the soft-substrate community, were chosen because they play an important ecological role in the Upper Mississippi River System. Sampling was based on a stratified random design and was conducted at about 125 sites per study area. Mean densities of organisms were weighted by strata for pool or reachwide estimates. Pools 4 and 13 had the highest mean number of mayflies (178.4 and 181.6 m^{-2}, respectively) and midges (81.5 and 39.8 m^{-2}, respectively). Fingernail clam estimated mean densities were highest in Pool 13 (276.3 m^{-2}). Overall, the impounded areas, including Lake Pepin, and the contiguous backwaters tended to support the highest densities of mayflies, fingernail clams, and midges. Substrates with predominantly a silt clay constituent supported the highest mean densities of mayflies, fingernail clams, and midges.

14. SUBJECT TERMS

Benthic aquatic macroinvertebrates, *Corbicula*, fingernail clams (Sphaeriidae), mayflies (Ephemeroptera), midges (Chironomidae), Mississippi River, zebra mussels (*Dreissena polymorpha*)

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